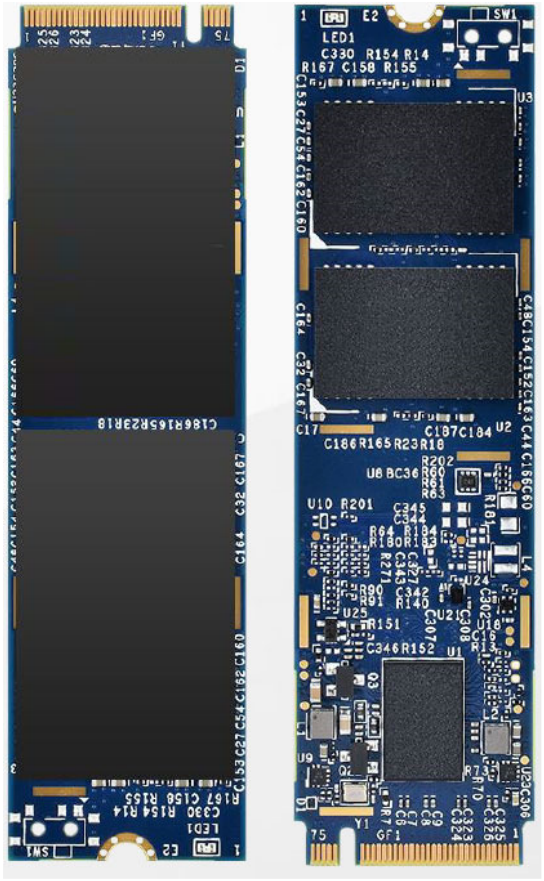
RoHS Compliant

PCIe Gen 3x4 - M.2 - 2280 PCIe Flash Module Series

Datasheet for PCIe Gen 3x4 - M.2 2280 PCIe BICS3 TLC NAND based Flash Module

September 28, 2020

Revision 1.1



This Specification Describes the Features and Capabilities of the Standard and Industrial Temperature M.2 PCIe Interface Modules

Please Contact Fortasa Memory Systems Sales for any Custom Features Required For Your Specific Application

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Features:

- **PCIe Interface**
  - – PCIe Gen3 x 4
  - – Compliant with PCIe 1.3
  - – Compliant with PCI Express 3.1
- **Low power consumption (typical)**
  - – Supply voltage: 3.3 ± 5%V
    - – Active mode: 1235 mA
    - – Idle mode: 245 mA
- **NAND flash type: 3D NAND – BICS3 TLC**
- **MTBF (hours):** >3,000,000
- **Capacity**
  - Single Side - 120GB
  - Double Side - 240GB, 480GB, 960GB, 1920GB
- **Temperature ranges**
  - – Operation:
    - Standard: 0°C to 70°C
    - Industrial: -40°C to 85°C
  - – Storage: -40°C to 100°C
- **Performance**
  - – Interface burst read/write: 4 GB/sec
  - – Sustained Performance
    - –Read: up to 1695 MB/sec
    - –Write: up to 1685 MB/sec
    - –Random read 4K: up to 189,000 IOPS
    - –Random write 4K: up to 144,000 IOPS
- **Intelligent endurance design**
  - – Built-in hardware LDPC based ECC algorithm
  - – Global wear-leveling scheme together with dynamical block allocation to significantly increase the lifetime of a flash device and optimize the disk performance
  - – Flash bad-block management
  - *– Power Failure Management*
  - *– ATA Secure Erase*
  - *– SMART Command*
  - *– Trim Command*
- **Connector Type**
  - – 75-pin M.2 module pin-out
- **Form factor**
  - – M.2 2280 PCIe Module Form Factor
  - – Single side: 22.00 x 80.00 x 2.38, unit: mm
  - – Double side: 22.00 x 80.00 x 3.88, unit: mm
  - – HeatGuard: 22.00 x 80.00 x 4.08 (max), unit: mm
- **Thermal Sensor for Temperature Management**
- **Endurance in (in drive writes per day: DWPD)**
  - – 120 GB: 3.42DWPD
  - – 240 GB: 3.37 DWPD
  - – 480 GB: 3.15 DWPD
  - – 960 GB: 3.00 DWPD
  - – 1920 GB: 3.25 DWPD

Table of Contents

1 Product Description

1.1 General Description

Fortasa's M.2 PCIe 2280 Flash module is a high-performance, PCIe interface, solid state drive (SSD) designed to replace a conventional PCIe interface hard disk drive. This module supports industry standard PCIe protocol and can be plugged into a standard PCIe connector commonly found in rugged laptops, military devices, thin clients, Point of Sale (POS) terminals, telecom, medical instruments, surveillance systems and industrial PCs.

The M.2 PCIe 2280 module offers capacities of up to 2TB, providing full support for the PCIe high-speed interface standard. It can operate at sustained access rates of more than to 1700 megabytes per second, which is much faster than other solid-state or traditional HDD drives currently available on the market. **Manufactured using 3D BICS3 TLC NAND-flash, this SSD offers cost effective solution to high capacity storage needs.**

M.2 PCIe 2280 Flash Module offers high reliability global data wear-leveling scheme to allow uniform use of all storage blocks, increasing the lifetime of Flash media and optimizing drive performance. It also offers Self-Monitoring Analysis and Reporting Technology (S.M.A.R.T.) feature that follows the ATA/ATAPI specifications and uses the standard SMART command to read critical performance data from the drive. This capability monitors the drive accesses and provides the host with vital information about drive condition to schedule maintenance and service times.

1.2 Capacity Specification

Standard capacity specification of the PCIe M.2 Flash Drive product are shown in Table 1-1. The table lists the specific capacity and the default numbers of heads, sectors and cylinders (CHS) for each product line.

Table 1-1: Capacity specifications

Capacity	Total Bytes*	Total LBA**
120GB	120,034,123,776	234,441,648
240GB	240,057,409,536	468,862,128
480GB	480,103,981,056	937,703,088
960GB	960,197,124,096	1,875,385,008
1920GB	1,920,383,410,176	3,750,748,848

*Display of total bytes varies from file systems, which means not all of the bytes can be used for storage.
**Notes: 1 GB = 1,000,000,000 bytes; 1 sector = 512 bytes.
LBA count addressed in the table above indicates total user storage capacity and will remain the same throughout the lifespan of the device. However, the total usable capacity of the SSD is most likely to be less than the total physical capacity because a small portion of the capacity is reserved for device maintenance usages.

Please contact factory for any non-listed Flash Drive capacity or custom CHS requirement.

1.3 Performance Specification

Performance of the M.2 PCIe 2280 Flash Module is listed in Table 1-2.

Table 1-2: Performance specifications

Performance \ Capacity	120GB	240GB	480GB	960GB	1920GB
Sustained read (MB/s)	1460	1645	1645	1665	1695
Sustained write (MB/s)	525	1035	1605	1655	1685
Random Read IOPS (4K)	75,000	125,000	184,000	189,000	180,000
Random Write IOPS (4K)	100,000	132,000	139,000	144,000	133,000

Note:
Results may differ from various flash configurations or host system setting.
*Sequential performance is based on CrystalDiskMark 5.2.1 with file size 1,000MB.
**Random performance measured using IOMeter with Queue Depth 64.

1.3 Pin Assignments

This connector does not support hot plug capability. There is a total of 75 pins. 12 pin locations are used for mechanical key locations; this allows such a module to plug into both Key B and Key M connectors.

Figure 1-1: M.2 PCIe connectors

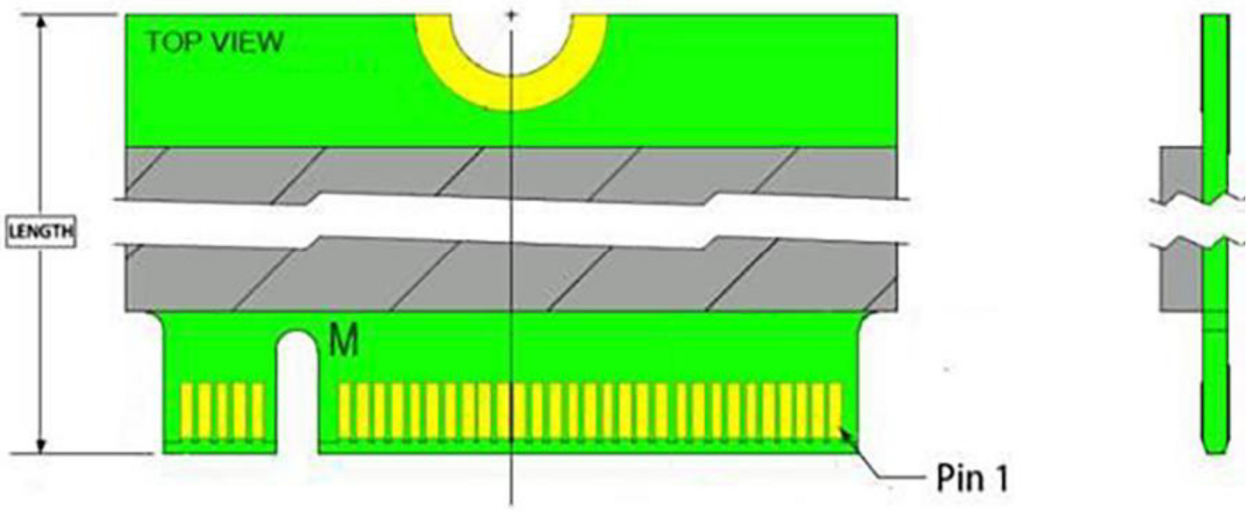

Table 1-4: Signal Segment

Pin	Signal	Description
1	GND	CONFIG_3 = GND
2	3.3V	Supply Pin, 3.3V
3	GND	Ground

4	3.3V	Supply Pin, 3.3V
5	PETn3	PCIe TX Differential signal defined by the PCI Express M.2 spec
6	No Connect	No Connect
7	PETp3	PCIe TX Differential signal defined by the PCI Express M.2 spec
8	No Connect	No Connect
9	GND	Ground
10	LED1#	Open drain, active low signal. These signals are used to allow the add-in card to provide status indicators via LED devices that will be provided by the system.
11	PERn3	PCIe RX Differential signal defined by the PCI Express M.2 spec
12	3.3V	Supply Pin, 3.3V
13	PERp3	PCIe RX Differential signal defined by the PCI Express M.2 spec
14	3.3V	Supply Pin, 3.3V
15	GND	Ground
16	3.3V	Supply Pin, 3.3V
17	PETn2	PCIe TX Differential signal defined by the PCI Express M.2 spec
18	3.3V	Supply Pin, 3.3V
19	PETp2	PCIe TX Differential signal defined by the PCI Express M.2 spec
20	No Connect	No Connect
21	GND	Ground
22	No Connect	No Connect
23	PERn2	PCIe RX Differential signal defined by the PCI Express M.2 spec
24	No Connect	No Connect
25	PERp2	PCIe RX Differential signal defined by the PCI Express M.2 spec
26	No Connect	No Connect
27	GND	Ground
28	No Connect	No Connect
29	PETn1	PCIe TX Differential signal defined by the PCI Express M.2 spec
30	No Connect	No Connect
31	PETp1	PCIe TX Differential signal defined by the PCI Express M.2 spec
32	No Connect	No Connect
33	GND	Ground
34	No Connect	No Connect
35	PERn1	PCIe RX Differential signal defined by the PCI Express M.2 spec
36	No Connect	No Connect
37	PERp1	PCIe RX Differential signal defined by the PCI Express M.2 spec
38	No Connect	No Connect
39	GND	Ground
40	SMB_CLK (I/O)(0/1.8V)	SMBus Clock; Open Drain with pull-up on platform
41	PETn0	PCIe TX Differential signal defined by the PCI Express M.2 spec

42	SMB_DATA (I/O)(0/1.8V)	SMBus Data; Open Drain with pull-up on platform
43	PETn0	PCIe TX Differential signal defined by the PCI Express M.2 spec
44	ALERT#(O) (0/1.8V)	Alert notification to master; Open Drain with pull-up on platform; Active low
45	GND	Ground
46	No Connect	No Connect
47	PERn0	PCIe RX Differential signal defined by the PCI Express M.2 spec
48	No Connect	No Connect
49	PERp0	PCIe RX Differential signal defined by the PCI Express M.2 spec
50	PERST#(I)(0/3.3V)	PE-Reset is a functional reset to the card as defined by the PCIe Mini CEM specification
51	GND	Ground
52	CLKREQ#(I/O)(0/3.3V)	Clock Request is a reference clock request signal as defined by the PCIe Mini CEM specification; Also used by L1 PM Sub-states
53	REFCLKn	PCIe Reference Clock signals (100 MHz) defined by the PCI Express M.2 spec
54	PEWAKE#(I/O)(0/3.3V)	PCIe PME Wake. Open Drain with pull up on platform; Active Low
55	REFCLKp	PCIe Reference Clock signals (100 MHz) defined by the PCI Express M.2 spec
56	Reserved for MFG DATA	Manufacturing Data line. Used for SSD manufacturing only. Not used in normal operation. Pins should be left N/C in platform Socket.
57	GND	Ground
58	Reserved for MFG CLOCK	Manufacturing Clock line. Used for SSD manufacturing only. Not used in normal operation. Pins should be left N/C in platform Socket.
59	CONFIG_2	Defines module type
60	Module Key M	Module Key
61	Module Key M	
62	Module Key M	
63	Module Key M	
64	Module Key M	
65	Module Key M	
66	Module Key M	
67	No Connect	No Connect
68	SUSCLK(32KHz) (I)(0/3.3V)	32.768 kHz clock supply input that is provided by the platform chipset to reduce power and cost for the module
69	No Connect	PEDET (NC-PCIe)
70	3.3V	Supply Pin, 3.3V
71	GND	Ground
72	3.3V	Supply Pin, 3.3V
73	GND	Ground

74	3.3V	Supply Pin, 3.3V
75	GND	Ground

1.4 LED Indicator Behavior

The behavior of the M.2 PCIe 2280 Flash Module LED indicators is described in Table 1-4.

Table 1-4: LED Behavior

Location	Status	Description
LED A	DAS	LED blinks when the drive is being accessed

2. Software Interface

2.1 Command Set

Table 2-1 summarizes the M.2 PCIe 2280 command set.

Table 2-1 Admin Commands

Opcode	Command Description
00h	Delete I/O Submission Queue
01h	Create I/O Submission Queue
02h	Get Log Page
04h	Delete I/O Completion Queue
05h	Create I/O Completion Queue
06h	Identify
08h	Abort
09h	Set Features
0Ah	Get Features
0Ch	Asynchronous Event Request
10h	Firmware Activate
11h	Firmware Image Download

Table 2-2 Admin Commands – NVM Command Set Specific

Opcode	Command Description
80h	Format NVM
81h	Security Send
82h	Security Receive
84h	Sanitize

Table 2-3 NVM Commands

Opcode	Command Description
00h	Flush
01h	Write
02h	Read
04h	Write Uncorrectable
05h	Compare
08h	Write Zeroes
09h	Dataset Management

2.2 S.M.A.R.T. Technology

S.M.A.R.T. is an acronym for Self-Monitoring, Analysis and Reporting Technology, an open standard allowing disk drives to automatically monitor their own health and report potential problems. It protects the user from unscheduled downtime by monitoring and storing critical drive performance and calibration parameters. Ideally, this should allow taking proactive actions to prevent impending drive failure.

SMART Attributes (Log Identifier 02h)

Bytes Index	Bytes	Description
[0]	1	Critical Warning
[2:1]	2	Composite Temperature
[3]	1	Available Spare
[4]	1	Available Spare Threshold
[5]	1	Percentage Used
[31:6]	26	Reserved
[47:32]	16	Data Units Read
[63:48]	16	Data Units Written
[79:64]	16	Host Read Commands
[95:80]	16	Host Write Commands
[111:96]	16	Controller Busy Time
[127:112]	16	Power Cycles
[143:128]	16	Power On Hours
[159:144]	16	Unsafe Shutdowns
[175:160]	16	Media and Data Integrity Errors
[191:176]	16	Number of Error Information Log Entries
[195:192]	4	Warning Composite Temperature Time
[199:196]	4	Critical Composite Temperature Time
[201:200]	2	Temperature Sensor 1 (Current Temperature)
[203:202]	2	Temperature Sensor 2 (N/A)
[205:204]	2	Temperature Sensor 3 (N/A)
[207:206]	2	Temperature Sensor 4 (N/A)
[209:208]	2	Temperature Sensor 5 (N/A)
[211:210]	2	Temperature Sensor 6 (N/A)
[213:212]	2	Temperature Sensor 7 (N/A)
[215:214]	2	Temperature Sensor 8 (N/A)
[511:216]	296	Reserved

SMART Parameters (Log Identifier C0h)

Byte	Length in Bytes	Description
0-255	256	Reserved
256-257	2	SSD Protect Mode
258-261	4	Host Read UNC Count
262-265	4	PHY Error Count
266-269	4	CRC Error Count
270-273	4	Total Early Bad Block Count
274-277	4	Total Later Block Count
278-281	4	Max Erase Count
282-285	4	Average Erase Count
286-289	4	Program Fail Count
290-293	4	Erase Fail Count
294-301	8	Flash Write Sector
302-305	4	Total Spare Block
306-309	4	Current Spare Block
310-313	4	Read Retry Count
314-511	210	Reserved

3. Flash Management

3.1 Error Correction/Detection

The M.2 PCIe 2280 implements a hardware LDPC (Low Density Parity Check) ECC algorithm.

3.2 Wear Leveling

All NAND flash devices are limited by a finite number of write cycles. Under a standard file system, frequent file table updates are mandatory. As a painful side effect of OS file overhead, some areas of flash address space wear out faster than others. As these certain sections get a substantially higher write occurrence the whole Flash Drive can wear out very quickly. This uneven wear would significantly reduce the lifetime of the whole device, even if majority of the Flash sectors are far from the write cycle limit. Fortasa's M.2 PCIe 2280 Flash Drive products offer advanced data wear leveling which distributes Flash writes evenly across the Flash Drive memory space. By utilizing this advanced wear leveling feature, the lifetime of the media can be significantly extended.

3.3 Power Failure Management

The Low Power Detection on the Flash controller initiates cached data saving before the power supply to the device drops too low for operation. This feature prevents the device from system crash and ensures data integrity during an unexpected brownout. This feature makes sure that there are no catastrophic failures of the Flash Drive due to system power glitches.

3.4 TRIM Command Support

Over time the performance of SSD degrades as user continually writes and erases data. The TRIM command "formats" the SSD to optimize the drive performance. A TRIM enabled SSD running an OS with TRIM support will stay closer to its peak performance without much performance variance.

3.5 Thermal Sensor

The M.2 PCIe 2280 SSD contains a Thermal Sensor that measures module temperature. The drive temperature can be obtained by polling SMART Command. When the device temperature reaches a pre-set temperature threshold, the module performance will be reduced to limit the power draw and prevent the module from overheating.

3.6 Thermal Throttling

Thermal throttling can monitor the temperature of the SSD equipped with a built-in thermal sensor via S.M.A.R.T. commands. This method can ensure the temperature of the device stays within temperature range by drive throttling, or reducing the speed of the drive when the device temperature reaches the pre-set threshold level to prevent overheating, guarantee data reliability, and prolong product lifespan. When the temperature exceeds the maximum threshold level, thermal throttling will be triggered to reduce performance to prevent hardware components from being damaged. Performance is only permitted to drop to the lower minimal performance to cool down the device's temperature. Once the temperature decreases to the minimum threshold value, transfer speeds will rise back to its optimum performance level.

3.7 NVMe Secure Erase

PCIe Secure Erase is an PCIe drive sanitize command currently embedded in most of the storage drives. Defined in PCIe specifications, PCIe Secure Erase is part of Format NVM command that allows storage drives to erase all user data areas. The erase process usually runs on the firmware level as most of the PCIe-based storage media currently in the market are built-in with this command. PCIe Secure Erase can securely wipe out the user data in the drive and protects it from malicious attack.

3.8 HeatGuard™

In many applications, SSDs are subject to challenging environmental conditions. If the ambient environment is already hot, and the prolonged high-performance SSD operation causes a increase in device temperature, the result could be damage or degradation of hardware or worst case data corruption. Given the high-power usage in PCIe modules, Fortasa developed HeatGuard, a heatsink that distributes heat dissipation in critical board components to prevent heat-related damage from occurring.

4. Environmental Specifications

4.1 Environments

Environmental specification of the M.2 PCIe 2280 Flash Drive series follows the MIL-STD-810F standard as shown in Table 4-1.

Table 4-1: Environmental specifications

Environment		Specification
Temperature	Operation	0°C to 70°C (Standard); -40°C to 85°C (Industrial)
	Storage	-40°C to +85°C
Vibration		Operating: 7.69 GRMS, 20~2000 Hz/random (compliant with MIL-STD-810G) Non-Operating: 4.02 GRMS, 15~2000 Hz/random (compliant with MIL-STD-810G)
Shock		Operating: 50(G)/11ms/half sine (compliant with MIL STD 202G) Non-operating: 1,500(G)/0.5(ms)/half sine (compliant with MIL STD 883K)
Humidity		RH 90% under 40°C

4.2 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in the M.2 PCIe 2280 drive. Based on provided component data, M.2 PCIe 2280 Flash Drive is rated at more than 3,000,000 hours.

Notes about the MTBF:

The MTBF is predicated and calculated based on “Telcordia Technologies Special Report, SR-332, Issue 2” method.

4.3 Certification and Compliance

The M.2 PCIe 2280 complies with the following standards:

- CE
- FCC
- RoHS
- MIL-STD-810G

4.4 Endurance

The endurance of a storage device is predicted by a JEDEC approved test methodology. The data, reported in Drive Writes Per Day, is based on several factors related to device architecture and product usage, such as the amount of data written into the drive, block management conditions, and daily workload for the drive. Please contact Sales to learn more about the DWPD analysis and calculations.

Capacity	DWPD
120GB	3.42
240GB	3.37
480GB	3.15
960GB	3.00
1920GB	3.25

Notes:

- This estimation complies with JEDEC JESD-219, enterprise endurance workload of random data with payload size distribution.
- Flash vendor guaranteed 3D NAND TLC P/E cycle: 3K
- WAF may vary from capacity, flash configurations and writing behavior on each platform.
- 1 Terabyte = 1,024GB
- DWPD (Drive Writes Per Day) is calculated based on the number of times that user overwrites the entire capacity of an SSD per day of its lifetime during the warranty period. (3D NAND TLC warranty: 2 years)

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5. Electrical Specification

5.1 Operating Voltage

Caution: **Absolute Maximum Stress Ratings –** Applied conditions greater than those listed under "Absolute Maximum Stress Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these conditions or conditions greater than those defined in the operational sections of this data sheet is not implied. Exposure to absolute maximum stress rating conditions may affect device reliability.

Table 5-1: Operating range

Range	Ambient Temperature	3.3V
Standard	0°C to +70°C	3.3V ±5%
Industrial	-40°C to +85°C	

5.2 Power Consumption

Tables 5-2 lists the M.2 PCIe 2280 power consumption.

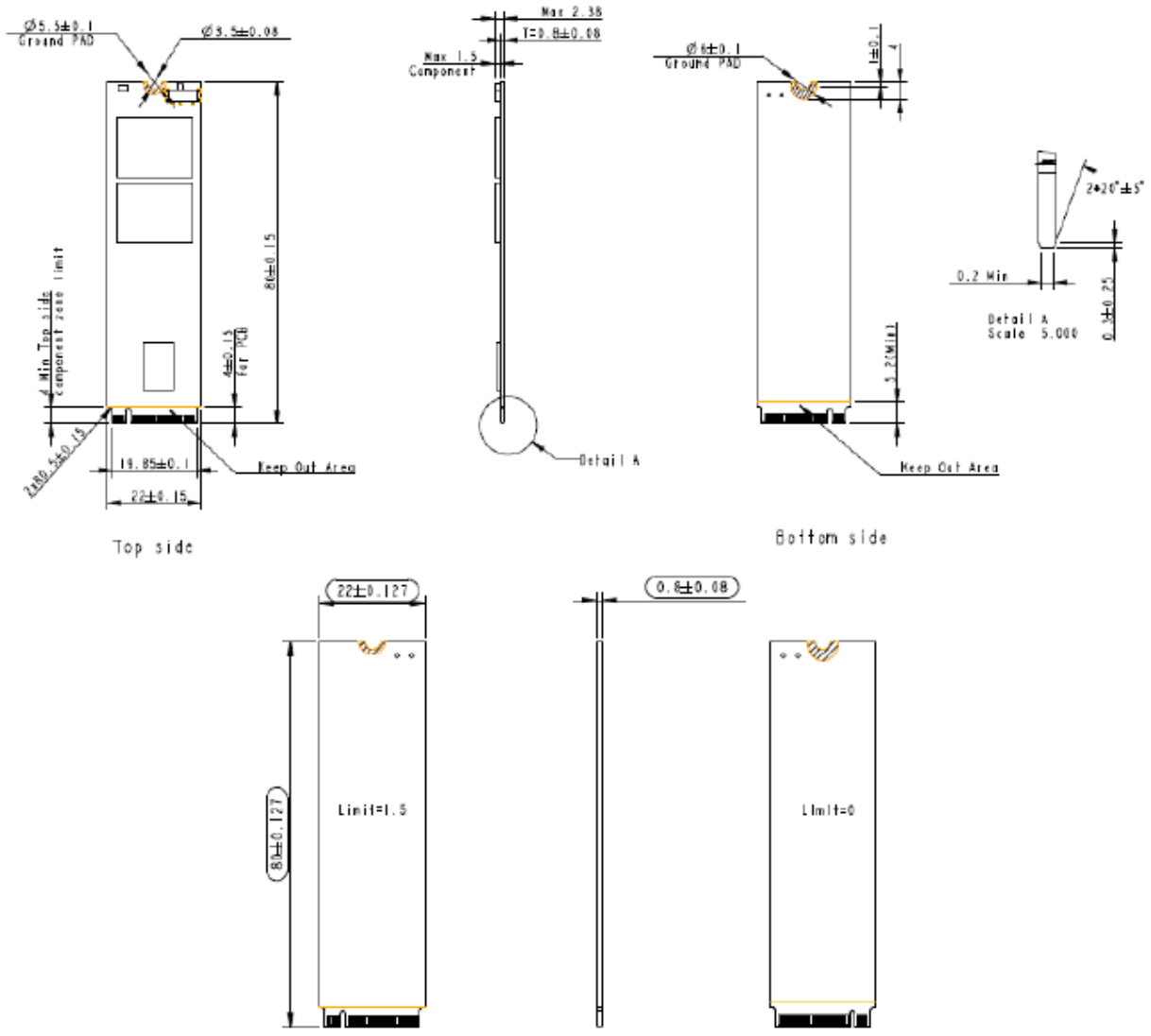
Table 5-2 M.2 PCIe 2280 power consumption (typical)

Performance \ Capacity	120GB	240GB	480GB	960GB	1920GB
Active Mode (mA)	895	1030	1135	1205	1235
Idle Mode (mA)	235	235	245	235	240

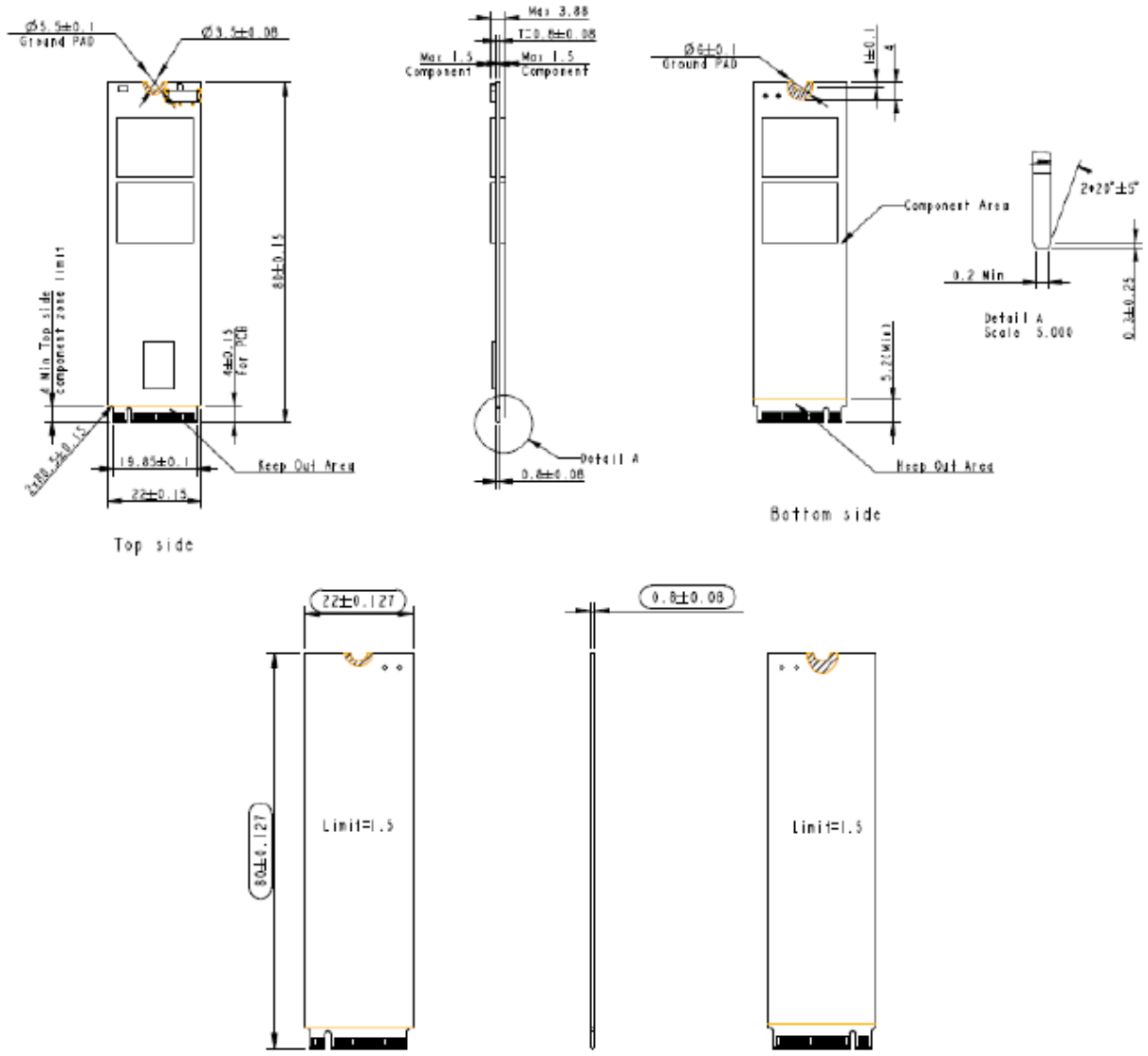
Note:
*All values are typical and may vary depending on flash configurations or host system settings.
**Active power is an average power measurement performed using CrystalDiskMark with 128KB sequential read/write transfers.

6. Physical Characteristics

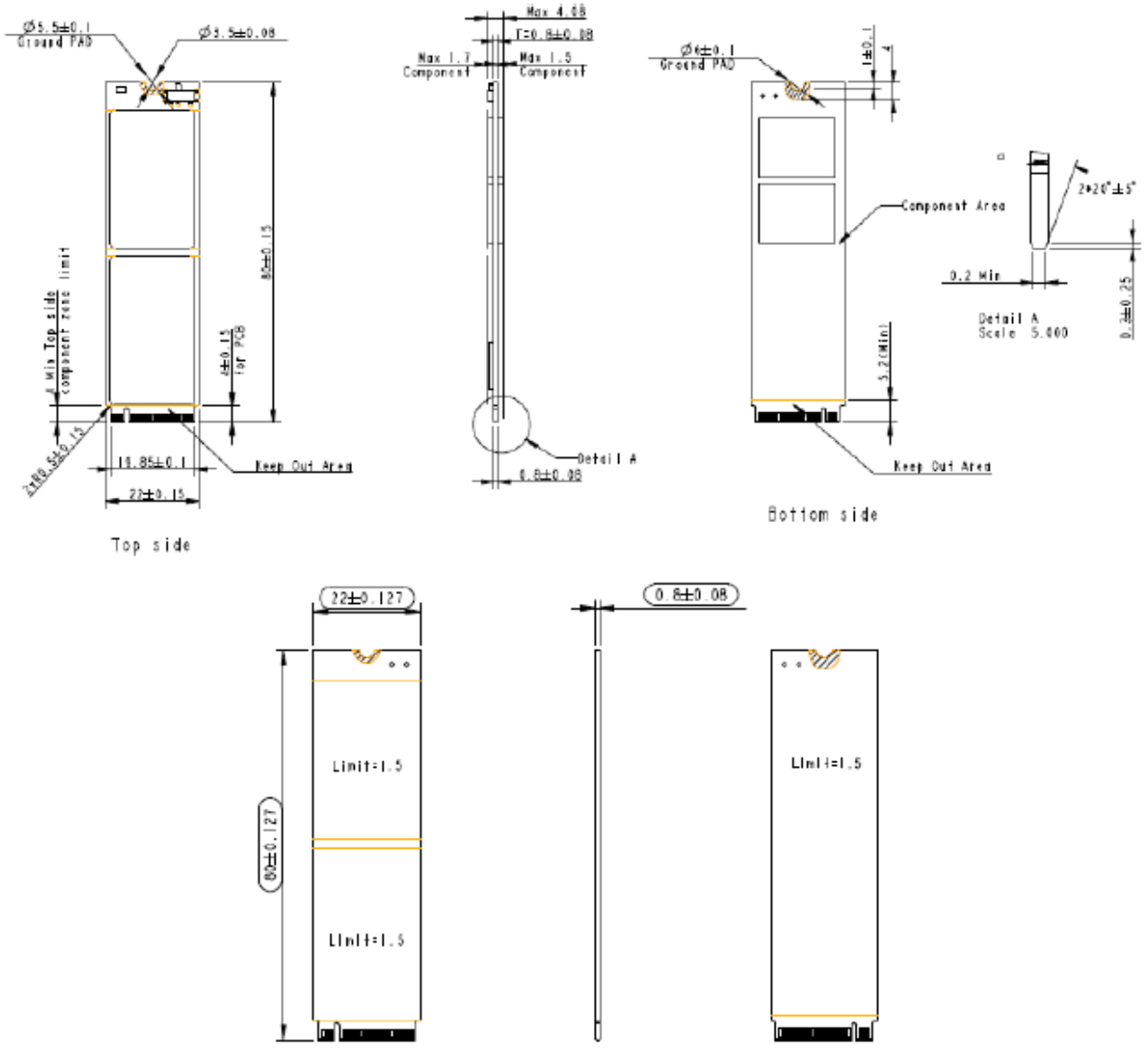
6.1 Dimensions – Single Side



6.2 Dimensions – Double Side



6.3 Dimensions – HeatGuard



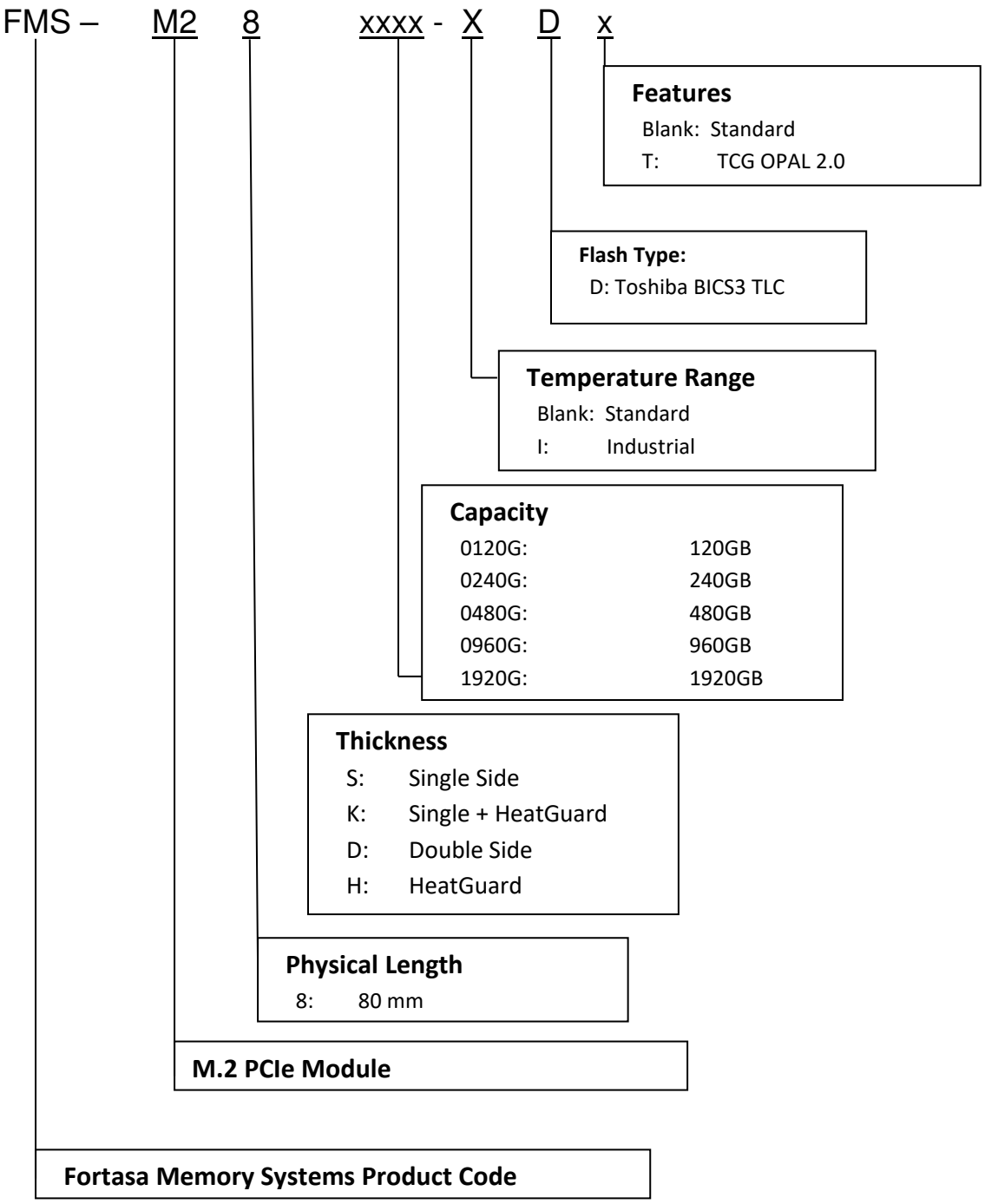
6.3 Net Weight

STANDARD TEMPERATURE	
Capacity	**Net Weight (g ±5%)**
120GB	5.33
240GB	6.06
480GB	6.03
960GB	6.39
1920GB	6.50

INDUSTRIAL TEMPERATURE	
Capacity	**Net Weight (g ±5%)**
120GB	6.53
240GB	7.26
480GB	7.23
960GB	7.59
1920GB	7.70

7. Product Ordering Information

7.1 Product Code Designations



7.2 Valid Combinations

Standard Configuration

Capacity	Standard Temperature Model Numbers	Industrial Temperature Model Numbers
120GB	FMS-M28S0120G-AD	FMS-M28K0120G-IAD
240GB	FMS-M28D0240G-AD	FMS-M28H0240G-IAD
480GB	FMS-M28D0480G-AD	FMS-M28H0480G-IAD
960GB	FMS-M28D0960G-AD	FMS-M28H0960G-IAD
1920GB	FMS-M28D1920G-AD	FMS-M28H1920G-IAD

TCG OPAL 2.0 Enabled Configuration

Capacity	Standard Temperature Model Numbers	Industrial Temperature Model Numbers
120GB	FMS-M28D0120G-ADT	FMS-M28K0120G-IADT
240GB	FMS-M28D0240G-ADT	FMS-M28K0240G-IADT
480GB	FMS-M28D0480G-ADT	FMS-M28H0480G-IADT
960GB	FMS-M28D0960G-ADT	FMS-M28H0960G-IADT
1920GB	FMS-M28D1920G-ADT	FMS-M28H1920G-IADT

Note: Valid combinations are those products in mass production or will be in mass production. Consult your Fortasa sales representative to confirm availability of valid combinations and to determine availability of new product combinations

8. Revision History

Revision	Date	Description	Comments
1.0	9/1/2020	Initial Release	
1.1	9/28/2020	Added 1,920GB support	